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The effect of caffeine and Rhodiola Rosea, alone or in combination on 5km running performance in men

Original Investigation

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Abstract

Background: To examine the effect of acute R.*Rosea* ingestion, acute caffeine ingestion or combined caffeine and R.*Rosea* on 5km running time trial performance.

Methods: Twelve male, recreational exercisers (mean age ± S.D. = 24.6 ± 6 years) undertook 4 trials each (Placebo; Caffeine (3 mg/kg^{-1}), R.*Rosea* (3 mg/kg^{-1}), Caffeine (3 mg/kg^{-1}) and R.*Rosea* (3 mg/kg^{-1})) in a double blind, randomised order.

Results: There was a small but significant main effect of treatment for 5km run time (P = .048) where performance was faster in the presence of caffeine compared to placebo but not between any other combination of trials. Heart Rate, Blood Lactate and RPE all increased with Km run, irrespective of substance ingested (all P<.05). Scores for Felt Arousal increased pre ingestion to post ingestion (P = .028) and were maintained to post exercise (P = .026) irrespective of substance ingested. There was a small, significant treatment X time interaction (P = .011, $P\eta^2$ =.255) for Feeling Scale scores, where post exercise feeling scale scores were significantly lower after caffeine ingestion compared to the other substances ingested.

Conclusions: Acute caffeine ingestion (3 mg·kg^{-1}) enhances 5km time trial performance undertaken on a treadmill and results in more negative affect post exercise as compared to ingestion of R.*Rosea,* combined R.*Rosea* and caffeine and placebo This study supports the efficacy of caffeine, but not R.*Rosea,* as an ergogenic aid for time running performance.

Keywords: Ergogenic; supplementation; feeling states; affect

Introduction

The performance enhancing effects of caffeine ingestion on endurance[1] and short term, high intensity performance[2] are well documented. However, less data is available that considers the effect of caffeine on shorter term endurance type activities (typically lasting <30min).[3] Bridge and Jones[4] reported that caffeine ingestion enhanced 8km run time by 1.3% and more recent research by O'Rourke et al,[3] reported that 5 mg/kg^{-1} caffeine resulted in small but significant improvements (1%) in 5km time trial performance in recreational and well-trained runners. This appears to be the only study that has examined the efficacy of caffeine ingestion on 5km running time, a commonly used race distance for trained and recreational runners alike. Thus, additional research may be warranted using this distance specifically.

There have also been recent calls to examine the efficacy of caffeine ingestion alongside ingestion of other supplements,[5] based on the rationale that many athletes consume multiple substances in the belief they are both ergogenic and synergistic without substantial scientific evidence for this assumption. This is an important point as although two given substances might theoretically act synergistically, when combined there may be practical considerations which confound a substance's positive effect. It is thus important to experimentally examine combination of substances to best direct applied nutritional guidance for athletes. Once such substance, Rhodiola Rosea (R.*Rosea*), has been cited as having a number of ergogenic benefits related to exercise[6,7] and may be synergistic with caffeine due to its recently purported effect as a natural opioid[6]. Recent studies have identified antioxidant and anti-inflammatory properties of R.*Rosea*,[8,9] and further work has suggested ingestion of R.*Rosea* appears to be effective, either acutely[10,11] or with daily supplementation,[11] for

reducing perceived fatigue, improving cognition,[9,12] as well as reducing markers of physiological and psychological stress.[13]

The efficacy of R.*Rosea* ingestion during exercise is unclear. Animal based research has shown increased swim time to exhaustion in rats.[8,14] In humans, some studies have shown no effect of R.*Rosea* ingestion on exercise performance[9,15] whilst others have supported its use.[17,18] For example, research by Noreen et al[18] reported that a 3 $mg \cdot kg^{-1}$ body mass dose of R.*Rosea* significantly decreased exercise heart rate, RPE and improved 6-mile time trial performance time. Subsequent work has reported that acute R.*Rosea* ingestion resulted in lower ratings of perceived exertion and increased mood state ratings during 30mins cycling at 70% $\dot{V}O_{2\ max}$.[11] Studies have suggested that R.*Rosea* acts to acutely increase endogenous opioid production or receptor sensitivity[7,17] subsequently impacting on brain dopamine and and attenuating perception of effort at a given workload.[18] However, as few studies have examined acute R.*Rosea* ingestion on exercise performance to date further data is needed on this topic.

As caffeine is a known ergogenic which has direct effects of muscle and the CNS and R.*Rosea* acts as an opioid, promoting more positive exercise based affective responses, it may be possible that when these substances are combined performance gains are augmented due to the mechanism by which both substances are purported to work. This study aims to build on the recommendations of Burke[5] by examining the effect of acute R.*Rosea* ingestion, acute caffeine ingestion or combined caffeine and R.*Rosea* on 5km running time trial performance in a population of recreationally-active men.

Method

Subjects

Following institutional ethics approval and informed consent, 12 male, recreational exercisers (mean age ± S.D. = 24.6 ± 6 years), recruited from University fitness classes/running groups, participated in this study. Inclusion criteria included being male and habitually engaged in recreational physical activity of more than 3 but less than 10 hours per week and not including formal competitive sports performance.

Design

This study employed a randomised within-participants double-blind cross-over design whereby participants visited the laboratory on 5 occasions in a well-rested and well hydrated state (one familiarisation trial, four experimental trials). All participants completed a health screen questionnaire prior to participation. All trials occurred in the morning for all participants and, for each participant, the 5 trials occurred at the same time of day with each participant completing all trials.

Methodology

All participants were asked to refrain from vigorous exercise and maintain normal dietary patterns in the 48 hours prior to testing and were asked to abstain from caffeine 24 hours before testing. Habitual caffeine intake was 119.3 ± 21.1 mg day. During the first visit participants completed a familiarization session. Here participants the exercise affect measures to be used in the subsequent experimental trials were presented and explained. In addition the participants also completed an incremental exercise test to assess VO_{2max}. The incremental exercise test was treadmill based (Woodway, Wisconsin, USA) and performed using the Jones[19] protocol for determination of maximal oxygen uptake. Expired gas was collected via an online breath by breath system (Metamax 3B, Cortex Biophysik, Leipzig,

Germany) with recording of VO_2 consumed, VCO_2 produced, respiratory exchange ration nd ventilation rate and volume. Heart rate (Polar Electro, Kempele, Finland) and rating of perceived exertion (RPE), using the Borg 6-20 RPE scale,[20] was recorded during the final 15 seconds of each workload. Recognised criteria for the attainment of $\dot{V}O_{2max}$ was employed.[21] Mean ± S.D. of participants' baseline $\dot{V}O_{2\,max}$ values was 56.1 ± 7.1 $ml \cdot kg^{-1} \cdot min^{-1}$.

Experimental protocol

On completion of the $\dot{V}O_{2max}$ testing and following a period of at least 72 hours participants completed four, 5-km running time trials in a fasted state. During each trial participants were instructed to complete 5-km in the fastest time possible. Trials were conducted on a Woodway Treadmill (Woodway, Wisconsin USA) with gradient set at 1% and with participants having access to speed controls. All other controls (eg gradient) and visual display information (eg running speed, time) was blinded from participants using a purpose built shield to prevent pacing during the trials.

Self-report of dietary intake was employed to assess dietary intake in the 24 hours prior to exercise trials. Participants were requested to maintain the same diet prior to each exercise trial in relation to general content of carbohydrate, fat and protein. They were also asked to refrain from consumption of caffeine and alcohol the day before each trial. Participants also verbally confirmed this was the case prior to each trial. This was used to ensure that caffeine and alcohol had not been consumed in the 24 hours prior to testing. Conditions were randomised, separated by 48-72 hours, and consisted of a R.*Rosea* condition where 3 $mg \cdot kg^{-1}$ body mass of R.*Rosea* (3% rosavins and 1% salidrosides, Indigo Herbs, Glastonbury, UK) was ingested, A caffeine condition where 3 $mg \cdot kg^{-1}$ body mass of caffeine (Myprotein, Cheshire, UK) was ingested, a combined R.*Rosea* and caffeine condition where

3 mg·kg^{-1} body mass of both substances was ingested and a placebo (3 mg·kg^{-1} body mass of maltodextrin, (MyProtein, Northwich, UK)) was ingested. Experimental solutions were administered double-blind. In addition to the relevant solute, each solution consisted of 4 ml.kg^{-1} tap water and 1 ml.kg^{-1} of double strength no added sugar orange squash (Sainsbury's, London, UK). The amount of total maltodextrin ingested was approximately 170 mg in the placebo condition and thus highly unlikely to have had any impact on exercise performance or metabolism.[18] The dose of R.*Rosea* used was based on the previous work using this substance.[11,17,18]

During each time trial, heart rate (monitored via Polar RS400, Polar Electro Oy, Kempele, Finland),blood lactate concentration (BLA: mmol/l) taken from a fingertip capillary blood sample (5 µl, Lactate Pro, Arkray Inc, Japan), and ratings of perceived exertion (RPE) using the Borg 6-20 scale[20] were recorded after every 1 kilometre. The memory-anchoring approach[22] was employed to anchor RPE scores before the experimental trials. Prior to substance ingestion, 60 min after ingestion (at the onset of each exercise bout) and immediately on completion of each exercise bout, participants completed the feeling scale (FS).[23] This 11 item, single item scale ranges from +5 (very good) to -5 (very bad) and is used to quantify pleasure/displeasure. The Felt Arousal Scale (FAS) was also employed as a measure of state arousal.[24] This is a six item scale ranges from 1 (low arousal) to 6 (high arousal). Participants were introduced to these scales on first visit to the laboratory (prior to establishment of $\dot{V}O_{2max}$). Standardised instructions for completing the FS and FAS were read to participants at the beginning of each trial.

Statistical Analysis

Data were analysed in a number of ways. A repeated measures analysis of variance (ANOVA) with substance ingested as the within subjects factor was used to examine any differences in total 5km time between conditions. In order to examine any within trial variation a 4 (substance ingested) X 5 (time per km) ways repeated measures ANOVA was used to examine any differences in running time per kilometre between the four conditions. A series of 4(substance ingested) X 5 (time point) ways repeated measures ANOVAs were used to examine any changes in heart rate, BLa and RPE at each kilometre of the time trial. A series of 4 (substance ingested) X 3 (time point, pre ingestion, post ingestion but pre exercise and post exercise) ways repeated measures analysis of variance was used to examine any differences in perceptions of arousal and pleasure/displeasure. Where any significant differences were discovered Bonferroni pairwise multiple comparisons were used to determine where the differences lay. Partial η^2 was used as a measure of effect size, statistical significance was set at P = .05 a priori, and the Statistical Package for Social Sciences (Version 22) was used for all analysis (SPSS inc, Illinois, USA).

Results

There was a small but significant main effect of treatment for 5km run time ($F_{3,33} = 2.935$, P = .048, $P\eta^2 = .211$; Table 1). Post-Hoc analysis indicated significant differences between placebo conditions and caffeine conditions (Mean diff = 78.6, P = .024) but not between any other combination of trials (all P>.05). There was a trend (P = .06) for 5km run to be faster in the caffeine condition compared to the R.*Rosea* condition. Mean ± SE of 5km time trial across treatment conditions is presented in Figure 1.

181 ***Table 1 Here***

182

183

184 When data were considered using individual time per kilometre and across treatment
185 conditions, the small main effect for total time remained (P = .048, $P\eta^2$ = .211) and there was
186 a moderate significant main effect for time per kilometre (P = .001, $P\eta^2$ = .340). In regard to
187 main effect of treatment condition, the results using this analysis were identical to those
188 presented above for total time. For the main effect for time per kilometre, post-hoc analysis
189 indicated that the final kilometre was run significantly faster than kilometres 1 -4 (all P =
190 0.08 or better, See Figure 2). Mean ± SE data of time per kilometre across the different
191 treatment conditions does appear to show different pacing strategies in Figure 2, particularly
192 for the placebo condition. However, there was no significant time per kilometre X treatment
193 interaction (P = .324).

194

195 In respect of heart rate (Table 2), there was no significant effect of treatment (P = .210) or
196 treatment X time interaction (P = .730). There was a large significant main effect for time (P
197 = .0001, $P\eta^2$ = .703).These findings were mirrored for BLa (Table 2) with no significant
198 effect of treatment (P = .132) or treatment X time interaction (P = .721) but a large significant
199 main effect for time (P = .0001, $P\eta^2$ = .803) and also for RPE (Table 2) where again there
200 was no significant effect of treatment (P =. 300) or treatment X time interaction (P = .566)
201 but a large significant main effect for time (P = .0001, $P\eta^2$ = .927). In each case, HR, BLa
202 and RPE significantly increased with each successive Km ran, irrespective of substance
203 ingested. These main effects are presented in Figure 3a, b and c.

Table 2 Here

When measures of affect were examined, results from a 4 (treatment) X 3 (time, Pre ingestion, post ingestion, post exercise) for scores on the Felt Arousal Scale indicated no significant main effect for treatment (P = .505) or time X treatment interaction (P = .335). There was however a large significant main effect for time (P = .009, $P\eta^2$ = .546, See Figure 4) whereby felt arousal increased pre ingestion to post ingestion (P = .028) with the difference also being significantly different from pre ingestion to post exercise (P = .026) but with no difference between post ingestion and post exercise (P = .084). Mean ± SE and 95% Confidence Intervals for felt arousal scores and Feeling scales scores pre ingestion, post ingestion and pre exercise and post exercise across placebo, R.*Rosea*, caffeine and combined caffeine and R.*Rosea* trials is presented in Table 3.

Table 3 Here

When scores from the Feeling Scale were examined there was a small significant treatment X time interaction (P = .011, $P\eta^2$ =.255, See Figure 5). Post-Hoc analysis indicated no significant differences in feeling scale scores pre ingestion (P = .693) or post ingestion (P =.431). However, Post exercise feeling scale scores in the caffeine condition were significantly lower as compared to the Caffeine + R.*Rosea* condition (P = .027) and the

R.*Rosea* condition (P = .05). There were also no significant differences pre ingestion to post ingestion and post exercise for Placebo, R.*Rosea* and Caffeine + R.*Rosea* conditions (all P >.05). For the caffeine condition there was significantly lower feeling scales scores post exercise compared to pre ingestion (P = .019) and post ingestion (p = .001).

Discussion

The present study is the first to combine caffeine and R.*Rosea* when examining exercise performance. This is despite there being plausible evidence that both substances are ergogenic alone and that potentially, when combined might be synergistic, due to caffeine acting directly on muscle[25] and the CNS[1] and suggestions that R.*Rosea* results in increased endogenous opioid production.[17]

The results of the present study suggest that ingestion of 3 $mg \cdot kg^{-1}$caffeine has a significant and positive effect on 5km run time in recreationally active males. The ingestion of R.*Rosea* or R.*Rosea* combined with caffeine did not significantly improve 5km running performance. When compared against performance in the placebo condition, 5km time trial time following caffeine ingestion was approximately 5% faster than the placebo trial. Such a magnitude of change in the presence of caffeine is greater than that reported by O'Rourke et al[3] following ingestion of a larger bolus of caffeine ($5mg \cdot kg^{-1}$) for 5km run and by Bridge and Jones[4] following ingestion of 3 $mg \cdot kg^{-1}$caffeine for 8km run. Likewise, although not significant, there was a 3.5% improvement following R.*Rosea* ingestion and a 4% improvement following combined R.*Rosea* and Caffeine ingestion when compared against the placebo condition. The reason for the larger performance improvement seen in the caffeine trial may be attributed to a number of reasons. The participants utilised by O'Rourke et al[3] were a mixture of trained and non-trained runners and those used by Bridge and Jones[4]

were trained runners. Prior systematic review data suggested lack of standardisation of training status may be one reason for the equivocal nature of the effects of caffeine on exercise performance and that the effect of caffeine on performance may differ in individuals of different training status.[26] In the present study, recreationally active men who were not specifically running trained, nor were they competitive runners. Secondly, in both the aforementioned studies, experimental trials took place outdoors, providing ample opportunity for pacing by participants. The present study utilised a different methodology whereby participants ran on a treadmill and had access to buttons to increase or decrease running speed. There were no other available metrics to the participants, thus removing any explicit cues for pacing. This lack of feedback may have resulted in lesser likelihood of a belief effect interacting with the time trial task employed in the current study.

Taken collectively, these results would appear to support the ingestion of caffeine alone as a means to enhance 5km time trial running performance. This finding adds further support for the use of caffeine as a performance enhancer in short-term endurance activity.[3,4] The current results also question the validity of claims regarding the efficacy of acute R.*Rosea* ingestion as a means to enhance exercise performance.[18] Similarly, R.*Rosea* or combined caffeine and R.*Rosea* ingestion did not significantly influence the affect either after ingestion or after exercise. This is also contrary to prior research by Duncan and Clarke[11] using steady state exercise that suggested R.*Rosea* positively enhanced affect. The discrepancy in findings regarding R.*Rosea* ingestion in the present study compared to prior work[17,18] may be due to a number of reasons relating to the methodologies employed in prior work and the current study. In the study by DeBock et al[17] a time to exhaustion test was used. Authors have questioned the validity of this methodology because it does not mimic the demands of most athletic events which require individuals to cover a set distance in the quickest time possible.[27] Although this point was addressed in the subsequent study by

Noreen et al[18], their design made feedback data available to participants during the time trial task they used. This procedure is also problematic when examining the potential effects of ingesting substances as athletes may pace using the available feedback and substance ingestion can also elicit belief effects,[28] which can be both positive and negative[29]. In the present study, the use of a time-trial task without feedback would have limited any potential interaction of potential belief effects with time trial pacing, resulting in a more accurate demonstration of the effects of the various substances ingested. Of interest, in the present study, acute caffeine ingestion resulted in significantly greater negative affect (feeling states) post exercise compared to the other trials. Few studies have examined how affect changes as a consequence of substance ingestion and exercise making it difficult to explain the findings presented here. The results presented here are contrary to work by Astorino et al[30] which reported improved scores for feeling states during a 10km cycling time trial in the presence of caffeine compared to placebo. Athletes may therefore performance benefit from ingestion of caffeine, but not R.*Rosea*, for short term endurance running performance. The present study also illustrates the importance of investigating the combination of two potentially ergogenic substances on performance. Theoretically, there appears to be a basis for a synergistic effect of combining caffeine and R.*Rosea*. In practice, when these substances were combined, there appeared to be no advantage to ingestion of caffeine and R.*Rosea* over ingestion of a placebo. The reason for this is not known and it may be that when combined, additional side effects are realised (although none of these were reported by participants) which do not occur when either caffeine or R.*Rosea* are combined in isolation. Additional research would be needed to examine this point specifically.

The current study does have some limitations. We recruited participants who were recreationally active but were not trained athletes. It has been suggested that less fit individuals may experience greater fatigue and discomfort during exercise which may reduce

feelings of pleasure and compared to more highly trained individuals.[11] It may therefore be useful to compare the responses of participants of different training status in order to make more conclusive statements regarding the effect of the substances, either alone or in combination on variables such as, perception of exertion, arousal and pleasure. The assessment of affect immediately on completion of the running bouts might have resulted in elevated scores for feeling states due to the cessation of exercise as has been suggested previously.[31] It may be that the trajectory of pleasure and displeasure during and after exercise exhibits two distinct phases.[31] The first phase involves a decline or increase of affective responses during exercise, whereas the second phase involves an improvement or rebound of affective responses after exercise. As measures of affect were only taken on completion of the exercise bouts, the data presented here are only representative of the rebound phase of exercise in the presence of caffeine, R.*Rosea*, combined caffeine and R.*Rosea* and placebo. Future research should therefore, attempt to assess affect during exercise in addition to immediately on cessation in order to more effectively capture the time course of affective responses to exercise following ingestion of different substances.

Conclusions

The current study suggests that acute caffeine ingestion (3 $mg \cdot kg^{-1}$) enhances 5km time trial performance undertaken on a treadmill and also results in more negative affect post exercise as compared to ingestion of R.*Rosea*, combined R.*Rosea* and caffeine and placebo. As a consequence this study supports the efficacy of caffeine as an ergogenic aid but also suggests that acute ingestion of R.*Rosea* either alone or with caffeine does not enhance performance over a placebo.

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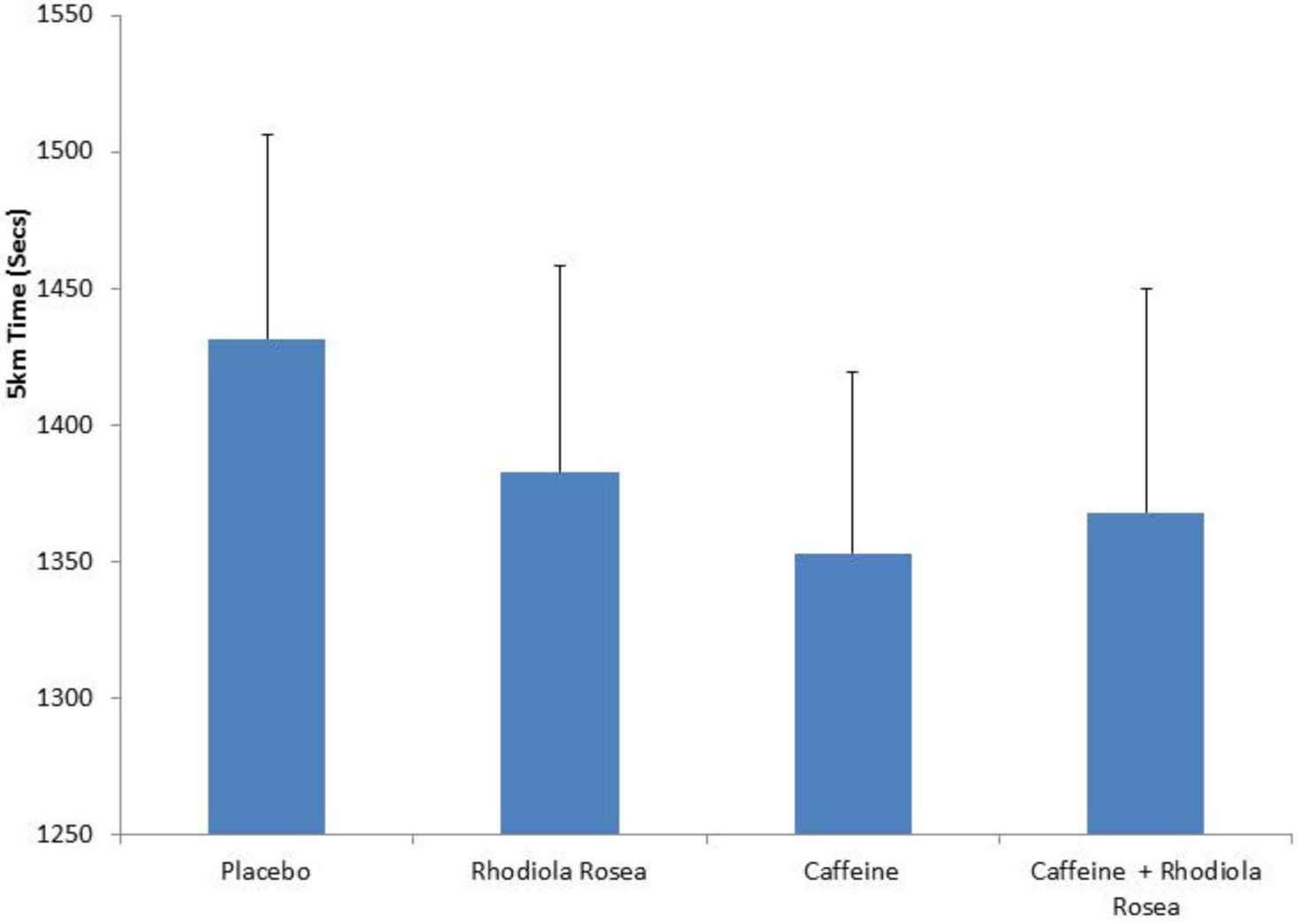
Figure 1. Mean ± SE of total 5km time across placebo, R.Rosea, caffeine and combined caffeine and R.Rosea trials

Figure 2. Mean ± SE of time per kilometre across placebo, R.Rosea, caffeine and combined caffeine and R.Rosea trials

Figure 3. Main effects (Mean ± SE) for a) heart rate (BPM), b) Blood lactate (mmol/L) , c) RPE (6-20), per kilometre irrespective of substance ingested.

Figure 4. Main effect for Felt Arousal per kilometre (Mean ± SE) irrespective of substance ingested.

Figure 5. Mean ± SE of Feeling Scale scores pre ingestion, post ingestion but pre exercise and post exercise across placebo, R.Rosea, caffeine and combined caffeine and R.Rosea trials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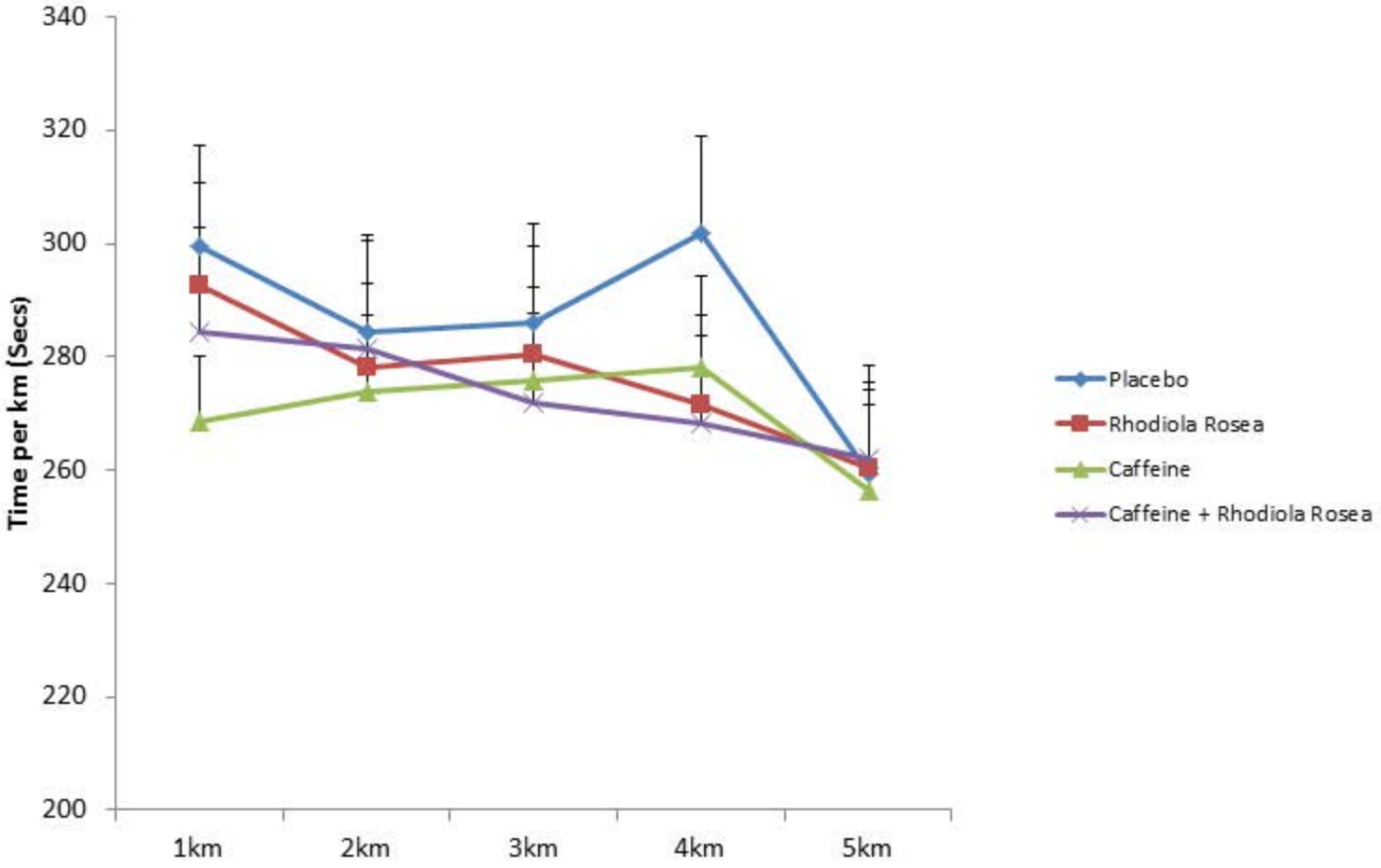
5km Time (Secs)
Placebo
Rhodiola Rosea
Caffeine
Caffeine + Rhodiola Rosea

Figure 1.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Time per km (Secs)
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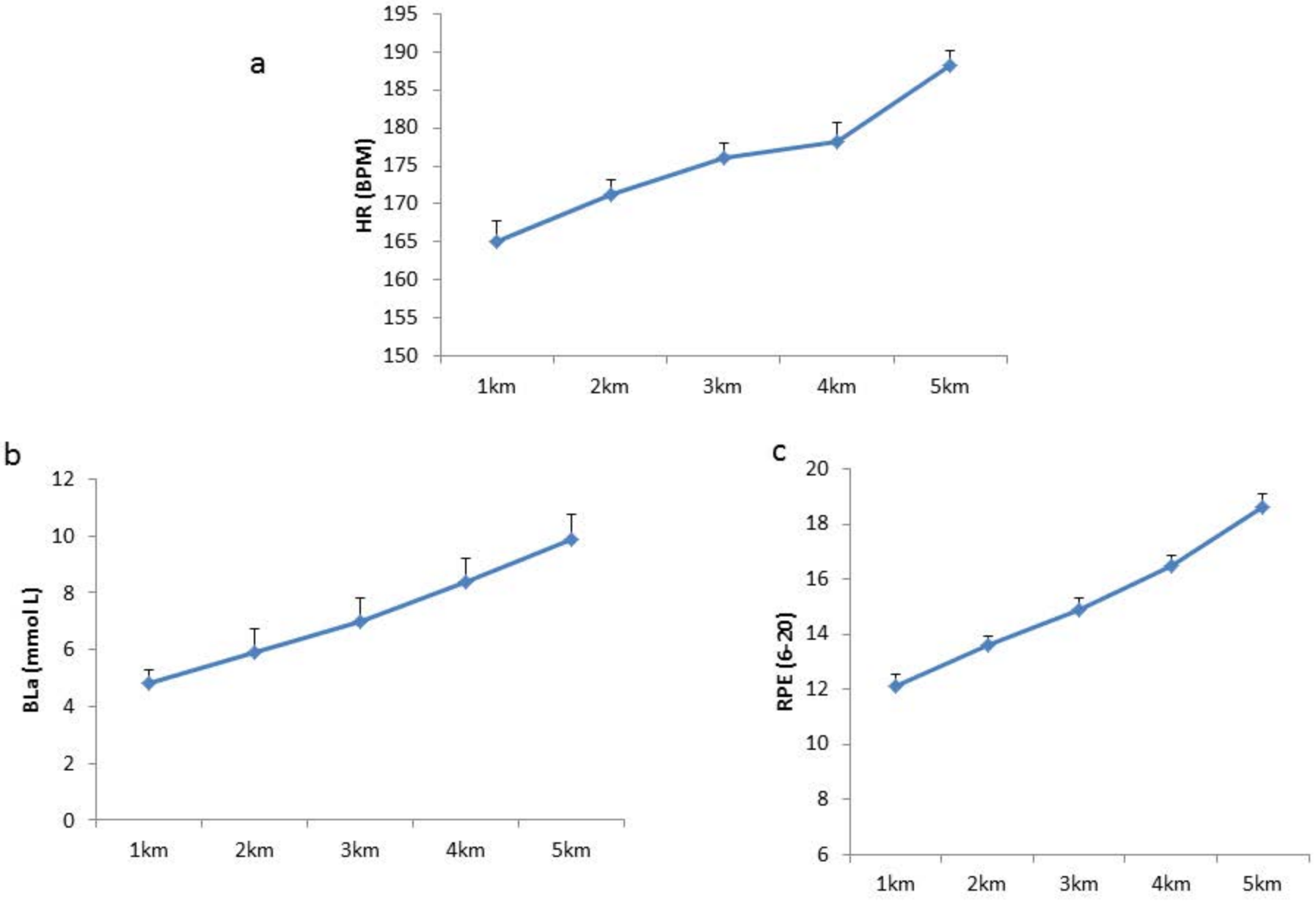
Placebo
Rhodiola Rosea
Caffeine
Caffeine + Rhodiola Rosea

Figure 2.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HR (BPM)
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2km
3km
4km
5km
b
BLa (mmol L)
12
10
8
6
4
2
0
1km
2km
3km
4km
5km
c
RPE (6-20)
20
18
16
14
12
10
8
6
1km
2km
3km
4km
5km

Figure 3.

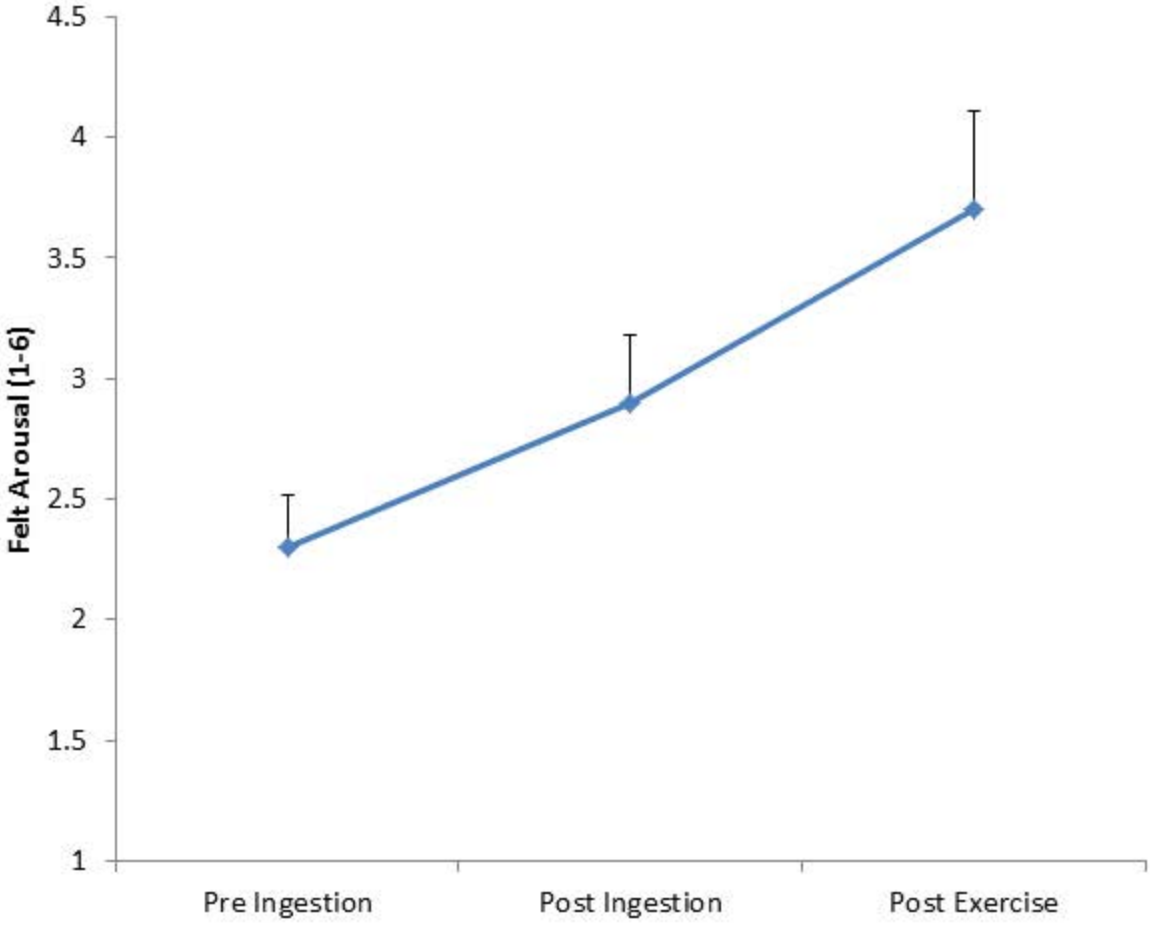
4.5
4
3.5
3
2.5
2
1.5
1
Felt Arousal (1-6)
Pre Ingestion
Post Ingestion
Post Exercise

Figure 4.

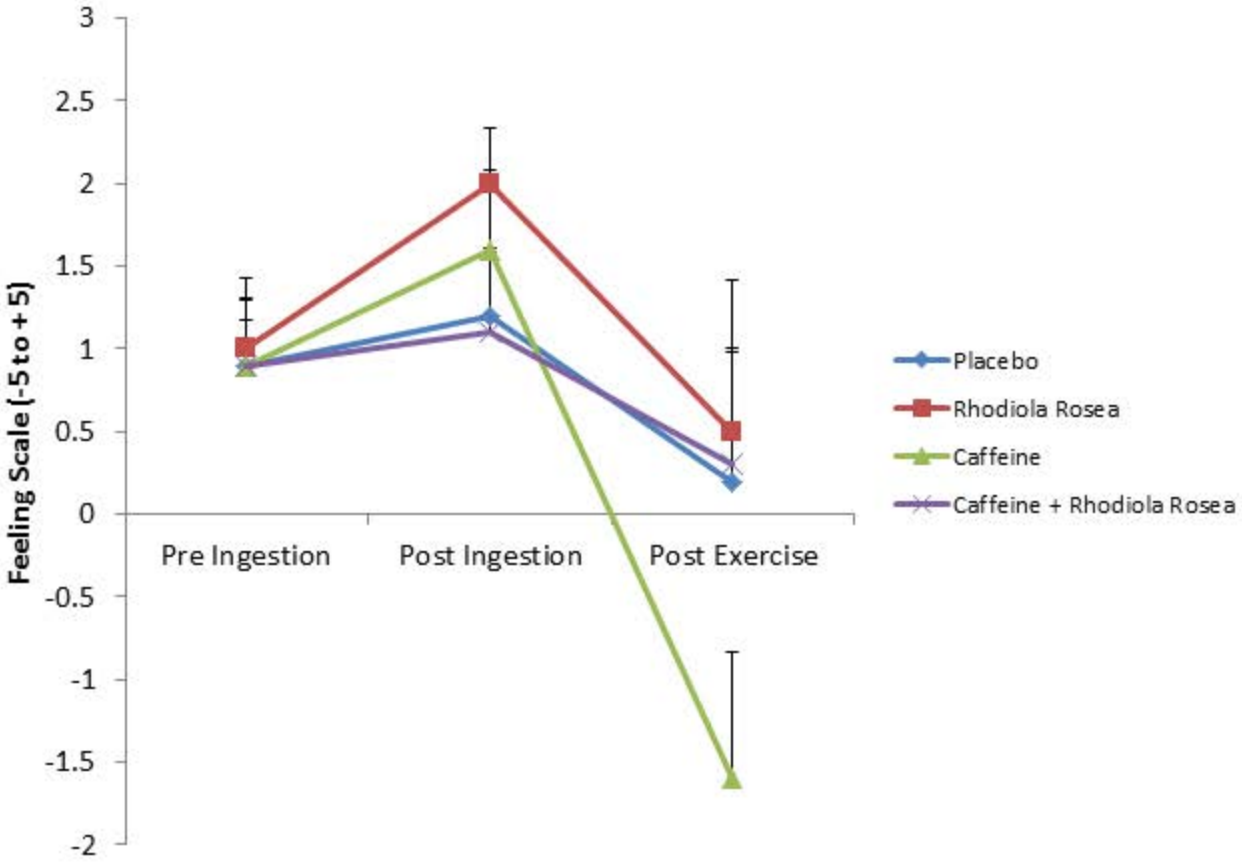
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Feeling Scale (-5 to +5)
Pre Ingestion
Post Ingestion
Post Exercise
Placebo
Rhodiola Rosea
Caffeine
Caffeine + Rhodiola Rosea

Figure 5.